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PROTOPLASM.

Allgemeine Biologie. By Prof. Dr. Max Kassowitz. Vols. i. and ii. Pp. xv + 411, and x + 391. (Vienna: Moritz Perles, 1899).

A BAD hypothesis is better than none at all, is a saying of which many have taken advantage; but able minds have agreed with the substance of the remark, and few can dissent from it in connection with that everlasting puzzle—Protoplasm. It is in vain to inveigh against the uselessness of speculations as to the structure or constitution, nature—what you will—regarding the physical basis of life, or regarding attempts to picture, however roughly, the movements, rearrangements and evolutions in that veritable witches' dance, the quadrilles of the molecules in which life consists. The inquiring mind is so constituted that it cannot resist the temptation to fashion some rough hypothesis as a tool wherewith to make one more attempt to pick the lock which hides the secret, and the criticism of the serious as to the futility of his efforts is no more powerful than the epigram of the debater to prevent him returning to the ruins of previous speculations, with renewed efforts to rebuild his frail image of something approaching, as nearly as may be, the inconceivably complex, and exposing it once more to the blows of the critic.

To those who are hopeless, let the more hopeful point out the difference in our present ideas of the nature of protoplasm from those of twenty years ago, and say whether no advances have been made.

In this extraordinarily well-written work, it is satisfactory to see that the word Biology is used in the sense of "the science of life," and not in the restricted and often unintelligible way so common in Continental works. Still more satisfactory is it to find here a carefully thought out plan of re-examination of the fundamental phenomena of life, and of "the physical basis of life," on which is erected a hypothesis with bold outlines and stately proportions, yet carefully and minutely fitted details, in conformity with the rapidly advancing knowledge of the last two decades.

The subject of "Allgemeine Biologie," as treated by the Viennese professor, resolves itself under the following headings:—

I. "Aufbau und Zerfall des Protoplasmas," forming the theme of the first volume, which is further subdivided into: (1) "Das Problem des Lebens und die Versuche zur Lösung desselben"; (2) "Aufbau des Protoplasmas"; and (3) "Zerfall des Protoplasmas."

II. The second volume is entitled "Vererbung und Entwicklung."

The third and fourth volumes are not yet to hand, but we are informed that they will deal with "Stoff- und Kraftwechsel der Thiere" and with "Nerven und Seele" respectively. That they will be eagerly looked for by all who have read the two at present under review is a safe prophecy.

Kassowitz takes his stand on the conviction—the reasons for which are given at great length in the first half of the first volume—that previous hypotheses as to the nature of protoplasm, based on assumptions that any structure visible after treatment can be translated in terms of its structure during life, break down on examination equally with those which would regard protoplasm as a mere emulsion; and that all attempts to explain what is going on in living protoplasm, which have for their basis the assumption that oxidations, reductions, and metabolic changes generally are carried out in the fluids bathing any such machinery of the protoplasm also fail to withstand criticism. The thermodynamic theory of life fails because the engine itself burns, and the value of a substance as food has no relation to its combustible value. It might have been added that Pfeffer had already shown this in his treatise "Zur Energetik der Pflanze." The osmotic theory of the botanists breaks down, because it attributes to the cell-sap an importance which a mere solution under such conditions does not possess; the fermentation theory fails to explain more than a few bye-phenomena of life, and has no help for us in questions concerning synthesis; the electro-dynamic theory breaks down because electric phenomena are least obvious just where we should most expect them. The molecular-physical theory assumes vibrations and the shaking asunder of molecules which are so stable that it is impossible to believe that they could be shattered and others escape under the conditions imposed; while the vitalistic theory is a mere confession that what is to be explained needs explanation.

Underneath or behind all the assumptions of micellæ, gemmules, biophores, determinants or other formed structural units, as well as all material networks, rods, spherules, fibrils, pellicles and foams, Kassowitz detects the question—Of what are these physiological units and structures composed? And he regards the fundamental fallacies underlying all previous hypotheses regarding the constitution and working of living protoplasm as chiefly two:—viz. the assumption that protoplasm is composed of proteids built up into some sort of more or less stable machinery, and that the chemical and other changes usually comprised in the term metabolism are carried on outside or merely in contact with this machinery—*e.g.* in a meshwork, or on the surface of the physiological units.

He therefore proposes to examine in detail, and step by step, what comes of deductions made from the hypothesis that protoplasm consists of molecules, in the chemical sense, but of extreme complexity, large volume, and very labile, linked one to another in series, and each requiring for its construction, not only proteids, but also fats, carbohydrates and the mineral salts known to be indispensable for life. And that every vital act consists in destructions and reconstructions of these molecules.

To obtain a coarse picture of this invisible structure we may suppose extremely tenuous fibrils of india-rubber joined up into a complex network and bathed in a fluid which contains the necessary ingredients for putting in new pieces wherever, by stretching the net too far, we break the elastic strands; such breakages will occur especially between the nodes, and immediately the gaps are bridged over again by new fibrils, or networks of such, further extension, breakage and restitution are possible.

The linked up chains and networks of protoplasm-molecules—which do not correspond to the networks of coagula of other hypotheses—are termed *stereoplasm*, the bath of liquid containing proteids, carbohydrates, fats, minerals, molecular oxygen, etc.—*i.e.* in which are dissolved all the food-materials as well as all the products of shattered molecules—is termed *hygroplasm*. The osmotic attraction for water of the newly formed molecules (imbibition) would set up pressures resulting in such ruptures of the linked up series.

Kassowitz supposes that every molecule of the *stereoplasm* is liable to disruption when stimulated by any mechanical shock, chemical reaction, thermal or electrical radiation, &c., and that the immediate results of the shattering of a given molecule are somewhat as follows. The products of disruption are partly atom-groups which at the moment of disruption display unsaturated affinities of so energetic a character that they split the molecules of atmospheric oxygen brought into the hygroplasm and combine to form saturated compounds such as CO_2 and OH_2; partly atom-groups containing nitrogen, which rearrange themselves into bodies such as proteids, and can be utilised again in building up new protoplasm-molecules, or temporarily stored, or excreted bodies of various kinds.

The combustions involved in the formation of CO_2 and OH_2, and constituting respiration, of course result in the evolution of heat: they are, in fact, explosions, and each such explosion acts as a new stimulus and shatters more protoplasm-molecules, with results and consequences as before, and it is this repeated play which constitutes the propagation of a stimulus—either irregularly in all directions or, if the stereoplasm is linked up more especially along certain tracts (nerves), in definite directions. The accumulation of metabolic products may result in blocking the meshworks, and so impeding the access of oxygen, and the activities slow down accordingly. In the pauses of rest between such destruction changes, the building up of new protoplasm-molecules is accomplished, and this act of restitutive construction is *assimilation*, while the interposition of the new molecules between those already in existence is *growth*.

In illustration of the kind of forces at work in the construction of a new protoplasm-molecule by assimilation, Kassowitz points to such phenomena as selective crystallisation, whereby a minute crystal of Glauber's salt, for instance, in a mixture of the same substance and saltpetre induces the crystallisation of the former only; and to such cases as mixtures of two optically active salts in which the crystallisation of one only is determined by introducing a minute crystal of like optical activity, and to other cases where substitutions of one atomic group by another can be brought about. These illustrations are not intended to serve as examples of what happens, but to show that the forces concerned in chemical attractions may well be those at the bottom of the phenomena of assimilation of like to like in the stereoplasm, or of the building up into the complex molecule of protoplasm of atom-groupings of similar or not very dissimilar nature; and although we have no hope of following the various stages in detail, it is argued that stereochemistry has at least taught that forms and configurations may result from such molecular phenomena as those indicated.

The arguments to show that the unstable protoplasm-molecule, the lability of which is increased by radiant energy absorbed from without, is itself devoid of oxygen, is capable of reducing highly oxidised food-substances, of absorbing water and setting up osmotic phenomena, of giving rise to metabolites of various kinds, &c., &c., are too long to reproduce here, and I must content myself with one illustration only, of the many given in the remainder of the first volume, to show the application of the hypothesis to special cases.

When the pseudopodium of an *Amoeba* has reached a certain development it suddenly retracts, or rather collapses, for Kassowitz regards the phenomenon as a rapid tumbling to pieces of the molecular structure, owing to stimulation: certain protoplasm-molecules are shattered, atom-groupings of carbon and hydrogen split the molecular oxygen and are at once burnt to CO_2 and OH_2, the heat-vibrations evolved during the combustion shattering more molecules, and so on, throughout that part of the mass. This process exhausted, a period of restitution sets in, and new molecules are built up from the fragments of proteids, carbohydrates, fats and mineral substances at disposal, and become interpolated between those which had escaped destruction, and a new pseudopodium is put out by assimilative growth. Among other arguments for the view that this is really a process of growth, Kassowitz points out that the rate of protrusion of such a pseudopodium, rapid as it appears under a high power, is really not much more rapid than the growth of a stem of asparagus, a mushroom or a bamboo.

The most interesting part of the second volume will, for most readers, be those dealing with the questions of variation and evolution.

Having elaborated his theory of the essential structure and mode of working of protoplasm, Kassowitz proceeds to consider the complexities which arise, first, on the differentiation of the nucleus and "germ-plasm," and then on the further divisions of labour involved in multicellular organisation. In these cases the nucleus, internal cells, &c., obtain for their immediate environment, not the outer world, but protoplasm exposed to the action of the latter and modified by it. Whereas undifferentiated protoplasm obtains its supplies of food and energy direct from the environment, the nucleoplasm can never do this, as it never comes in contact with it. Its protoplasm-molecules must select their assimilable materials from the fragments of shattered cytoplasm molecules, and *if any modifications in the modes of disruption and reconstruction of the molecules of the stereoplasm—i.e.* in the "somatoplasm" of authors—*have been brought about by the action of the environment*, the slightly altered atomic groupings and modes of disruption thus put at the disposal of the nucleoplasm—*i.e.* the "germ-plasm" of authors—will affect the building up and modes of disruption of the new molecules of this, and these in their turn react again, and so on.

This short summary of a long argument must serve to indicate the nature of the author's grounds for concluding that Weissmann's contention against the transmission of acquired characters cannot be upheld. It is

also the basis on which Kassowitz founds his theory of variation, which latter he regards as always due to the action of the environment, translated in slight differences in the mode of breaking down and reconstruction of protoplasm.

It is impossible to summarise vol. ii. in a review with any hope of doing justice to the criticisms—some of them undoubtedly clever—of contemporary writers on evolution, Weissmann especially coming in for lengthy and severe treatment, particularly with regard to the theory of determinants, and his peculiar views on the meaning of amphimixis, natural selection, and acquired characters. It must suffice to say that Kassowitz offers—assuming the validity of his fundamental hypothesis—what he regards as convincing arguments to prove the essential truth of Darwin's conclusions as to the inheritance of adaptations, of the effects of use and disuse—in short, of the gradually accumulated effects of the environment on the somatoplasm, until the latter is so altered as to affect the germ-plasm, and so fix and hand on the changes.

The author regards the theories of pangenesis and their like, equally with such as Haeckel's suggestions as to transmissions of modes of vibrations, as far too complex: his chief objections are that it is to him inconceivable how every structural part could be represented by a physical unit or by a mode of motion transferred to the germ-plasm, and that he cannot see how those who conceive this can get over the difficulty that such vibrations would annul each other as their paths cross, or that the pangenes, biophores, determinants, &c., would get lost on the road. Further, these latter units are, by hypothesis, themselves living, and hence the real difficulty is only shelved.

Kassowitz, however, only demands of his germ-plasm that it be made up of a certain, and probably not a very large number of similarly built and very complex, but not infinitely complex, molecules. He does not suppose that every form-unit of the future organism is represented, but that certain characteristic atom-groupings out of the chemical units of the somatoplasm are utilised in the architecture of the molecule of the germ-plasm, and that in ontogeny these atom-groupings make their effect felt, either directly or indirectly, by the way of correlations of various kinds.

This is true epigenesis. In the developing organism every part is formed anew, from a substance in which none is especially represented. The forms and arrangements which ensue are simply the results of the activities of the atom-groupings already there, working on the materials supplied. When these latter have been assimilated—*i.e.* built up into protoplasm molecules—they exert their cumulative effects on more substance, and also *modify those already present by serving as new environment*—and so the process of evolution proceeds. Every now and again a slight variant gets its play, and the results may be far-reaching; but, on the whole, the dominant play of the constellations of molecules at work leads to what we term uniformity—a relative term.

While fully appreciating and endorsing Darwin's conclusions as to the importance of artificial selection, Kassowitz appears to undervalue the power of natural selection, curiously enough, because he, like so many others, cannot imagine it to be effective in the early stages of adaptive changes. He thinks acquired characters must have reached a certain stage of perfection before natural selection can come into play, and argues that when such a stage is reached selection is unnecessary, because so many individuals have already got the adaptation. Kassowitz appears to me to here betray the position of a laboratory philosopher as opposed to a field-naturalist. His own hypothesis points to the laborious accumulation of the effects of repeated stimuli and repeated readjustments: some have survived, others and far more have perished—is this not natural selection? There seems to be some confusion of thought expressed in implications that natural selection is incompetent to explain the *origin* of variations, which primarily it was never intended to do.

In one or two cases, indeed, the Viennese professor appears to me to have completely misunderstood the position—to an extent so remarkable that the question obtrudes itself, whether the whole argument must not be vitiated into which such misapprehension has crept. To quote one instance only. He admits that the struggle for existence between closely allied varieties, races, or species has resulted in the death of some races, &c., but objects that many plants and animals in the past

"nicht auf diesem Wege ihren Untergang gefunden haben, sondern durch ungünstige äussere Bedingungen und feindliche Einwirkungen, also durch Trockenheit, Ueberschwemmung, Kälte, Nahrungsmangel oder überlegene Feinde vernichtet wurden, dass sie also nicht im Concurrenzkampfe, sondern in einem mit ungenügenden Mitteln geführten Abwehrkampfe unterlegen sind" (vol. ii. p. 131).

But what does all this imply if not selection due to the environment, and the struggle for existence?

To find a paragraph like this followed by the question—Is it conceivable that such struggle for existence can have led to any adaptive arrangement whatever? almost takes away one's breath, because it is so totally beside the issues raised by Darwin. The only explanation appears to be that Kassowitz must be combating some foreign misinterpretation of the views of the great master. In spite of these and other faults—I take it, no botanist will accept the explanation of geotropism (vol. i. p. 280)—this remarkable book appears to me to be a valuable contribution to the literature of evolution, well worth reading if only for the numerous criticisms and suggestions scattered throughout its fascinating pages. These, by the bye, are not few—there are nearly 750 pp. of text, and more than that number of notes. It may be that the glamour of the style and the beauty of the theme have led me to pass too lightly over the failings, and to over-estimate the good; but the good is there.

We have heard much of late about useful knowledge. From the point of view of those who regard all knowledge as "useless" which cannot be directly applied to the material improvement of man, the books before me are indeed of little worth; but to those who draw distinct lines between knowledge and learning—information and education—no apology will be needed for the conviction that a treatise of this kind is especially welcome at the present time. It is not only instructive, but stimulating to a degree, and of the highest educational value to the biologist of to-day. H. MARSHALL WARD.